Hearing Loss 101 – Part 1

Stacie Heckendorf
Educational Audiology Consultant – WESPDHH Outreach

Holly Kloiber
Speech Language Consultant – WESPDHH Outreach

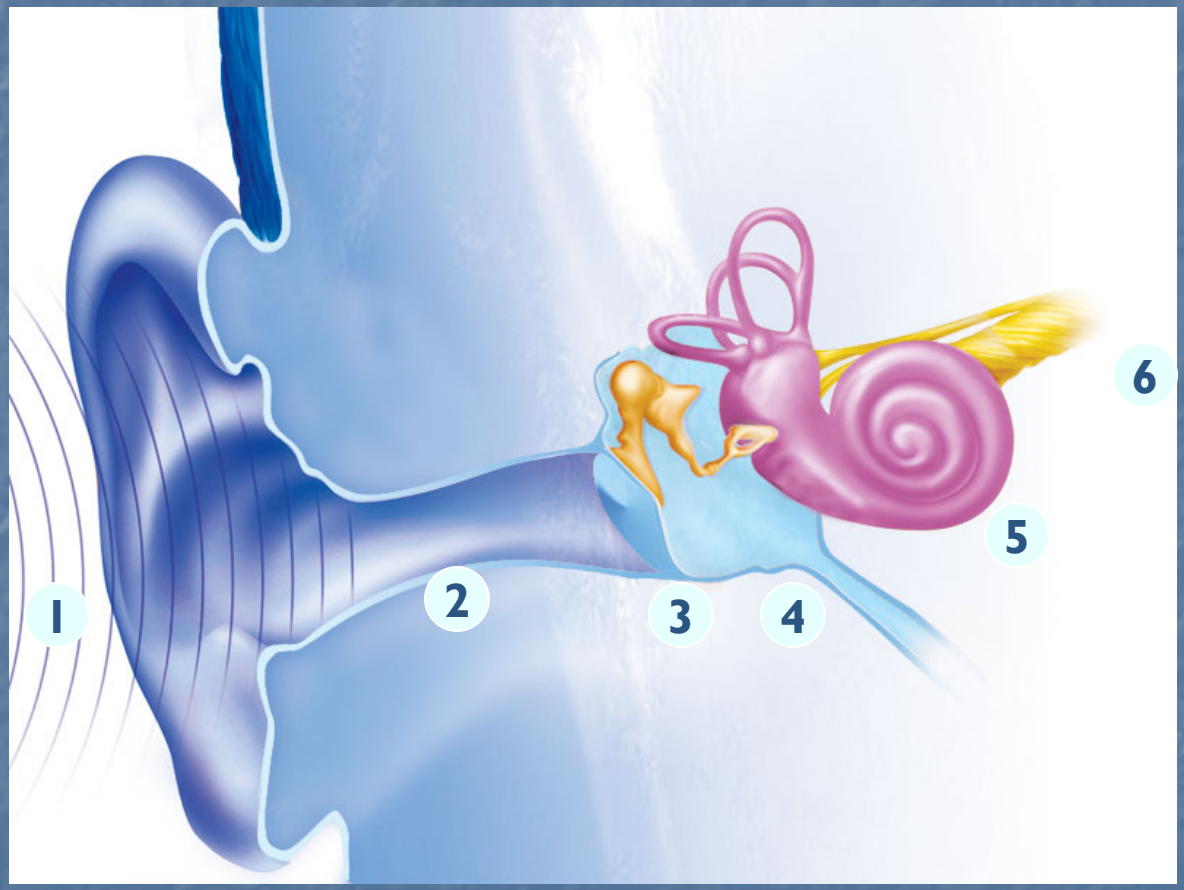
Agenda

- Sound / How We Hear
- Anatomy
- Measuring Hearing
- Types of Hearing Loss
- Degrees of Hearing Loss
- Amplification / Technology

Sound

- Definition: Sound is vibration, as it moves forward, air molecules get pushed together and then move back
- Hertz (Hz): frequency or pitch, speed of vibration (cycles per second) determines high or low tone
- Decibel (dB): loudness
- Audiogram: graph of hearing levels

The Ear and How We Hear



1 = Sound waves

2 = Ear canal

3 = Eardrum

4 = Middle ear

5 = Cochlea

6 = Hearing nerve

Process of Hearing

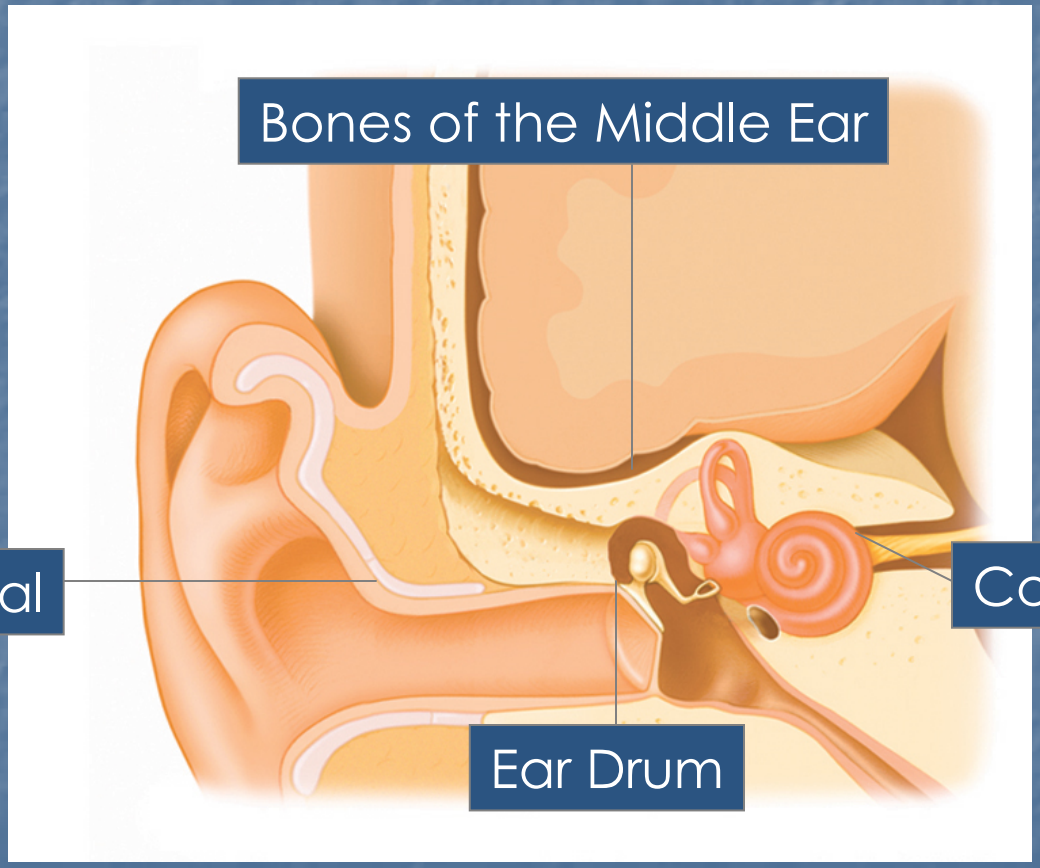
- Sound pushes eardrum
- Eardrum pushes the middle ear bones
- Stirrup/stapes pushes on the oval window
- Oval window moves fluid in the cochlea
- Moving fluid in cochlea stimulates hair cells / nerve in patterns
- Patterns travel up the brainstem

Anatomy of Hearing System

- Outer ear – pinna (auricle), ear canal
- Middle ear – eardrum, bones, oval window, Eustachian tube
- Inner ear – semicircular canals, cochlea, auditory nerve
- Brainstem – auditory nerve
- Brain – auditory cortex

How the Ear Works

Outer Ear | Middle Ear | Inner Ear



Testing Methods

- ABR – Auditory Brainstem Response
- OAE – Otoacoustic Emissions
- BOA – Behavioral Observation Audiometry
- VRA – Visual Response Audiometry
- CPA – Conditioned Play Audiometry
- AC - Air Conduction
- BC - Bone Conduction
- Tympanometry

ABR – Auditory Brainstem Response

- Also known as BSER, BEAR, etc.
- Child asleep or sedated
- Electrodes attached to head, earphones present clicks or tone bursts at different frequencies or dB and brain response measured
- Approximation of loss, can not differentiate conductive components
- Child does not need to respond
- Mostly high frequency info (2000-4000 Hz)
- No info on configuration or shape of loss

OAE – Otoacoustic Emissions

- Ear tip in canal presents sound, cochlea echoes back the sound, measure the sound that comes back
- Gives info on how outer hair cells are working
- Can identify a loss of 30 dB or greater
- Approximation of loss, can not differentiate conductive components
- Child does not need to respond
- Can test different frequencies

BOA – Behavioral Observation Audiometry

- Watch child to observe responses to sound
- Startle, stop moving, eye movement, head turn, etc.
- Usually done in sound field
- Approximation of loss
- Only have info on better ear
- Not precise regarding degree or configuration of loss

VRA – Visual Reinforcement Audiometry

- Child sits on lap or in high chair. Moveable toy or light at sound source lights up when child turns.
- Can be sound field or with earphones
- Can identify different frequencies and decibel levels
- Some children scared or not interested
- Need physical ability to remain upright
- Typically used 6 months – 2 years

CPA – Conditioned Play Audiometry

- Child learns to drop block when hear a sound.
- Can be in sound field or with earphones
- Typically used 18 months or older
- More interesting than VRA alone
- Can get frequency and decibel level information
- Need to alternate activities to maintain interest

Air Conduction Thresholds

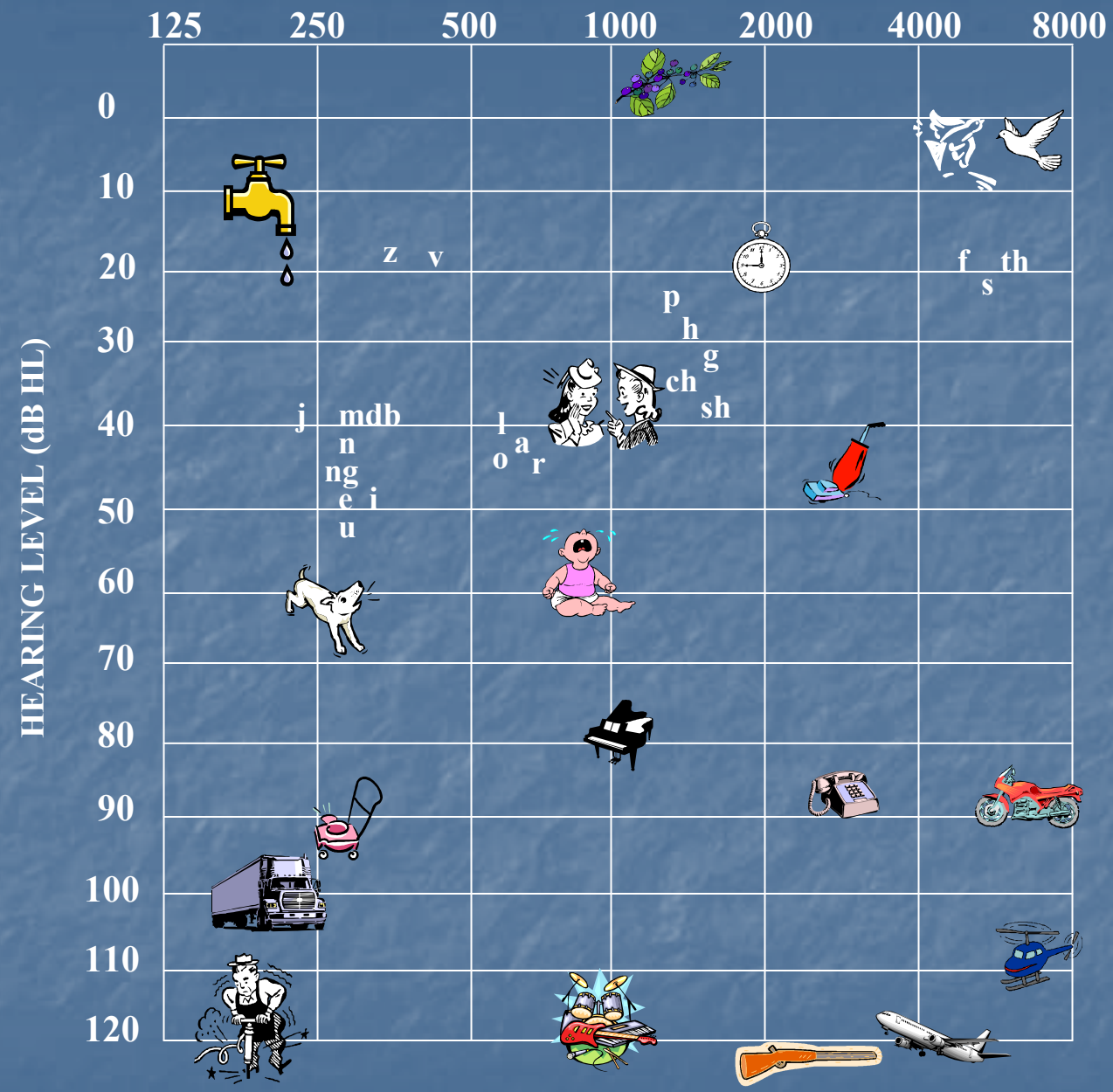
- Evaluates thresholds through whole system – outer, middle, inner ear
- Obtained through earphones or inserts
- Gives frequency and decibel information

Bone Conduction Thresholds

- Vibrator placed on forehead or mastoid
- Sound goes directly to nerve, bypasses outer and middle ear
- Helps differentiate conductive from sensorineural
- Gives frequency and decibel information

Tympanometry

- Tympanogram
  - Middle ear pressure
  - Eardrum mobility
  - Eustachian tube function
  - Continuity of middle ear bones
- Acoustic Reflex Thresholds
  - Contraction of middle ear muscles
  - Patterns give diagnostic information



AUDIOGRAM OF FAMILIAR SOUNDS

FREQUENCY IN CYCLES PER SECOND (HZ)

Audiogram Terms / Symbols

dB - Decibel
Hz - Hertz
X - Right Ear
O - Left Ear
S - Sound field
A - Aided thresholds
C - Cochlear Implant Thresholds

Audiology Terms

- Unilateral / Monaural – one ear
- Bilateral / Binaural – two ears
- Threshold – softest level of sound awareness
- NR – No Response
- CNT – Could not test
- SF – Sound field – sound presented through speakers

Speech Audiometry

SDT - Speech Detection Threshold

SRT - Speech Reception Threshold

WRS - Word Recognition Score

WDS - Word Discrimination Score

MLV - Monitored Live Voice

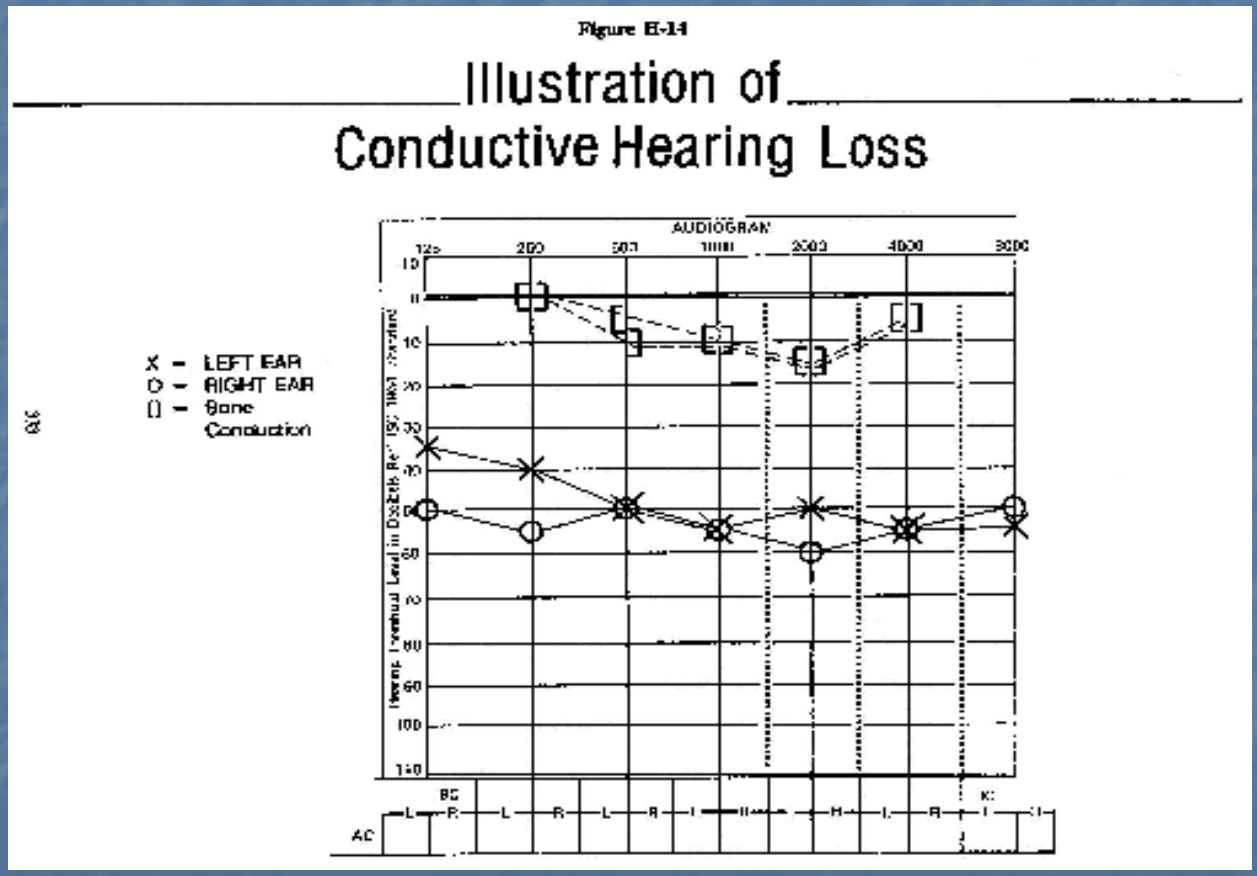
Types of Hearing Loss

- Conductive
- Sensorineural
- Mixed
- Auditory Neuropathy / Dyssynchrony
- Central Auditory Processing Disorder (CAPD)

Conductive Hearing Loss

- Transmission problem – something is preventing the sound from being conducted correctly
- Problem - outer or middle ear
- May be medically or surgically corrected
- Perception that sound is quieter
- Maximum conductive loss is 60 dB

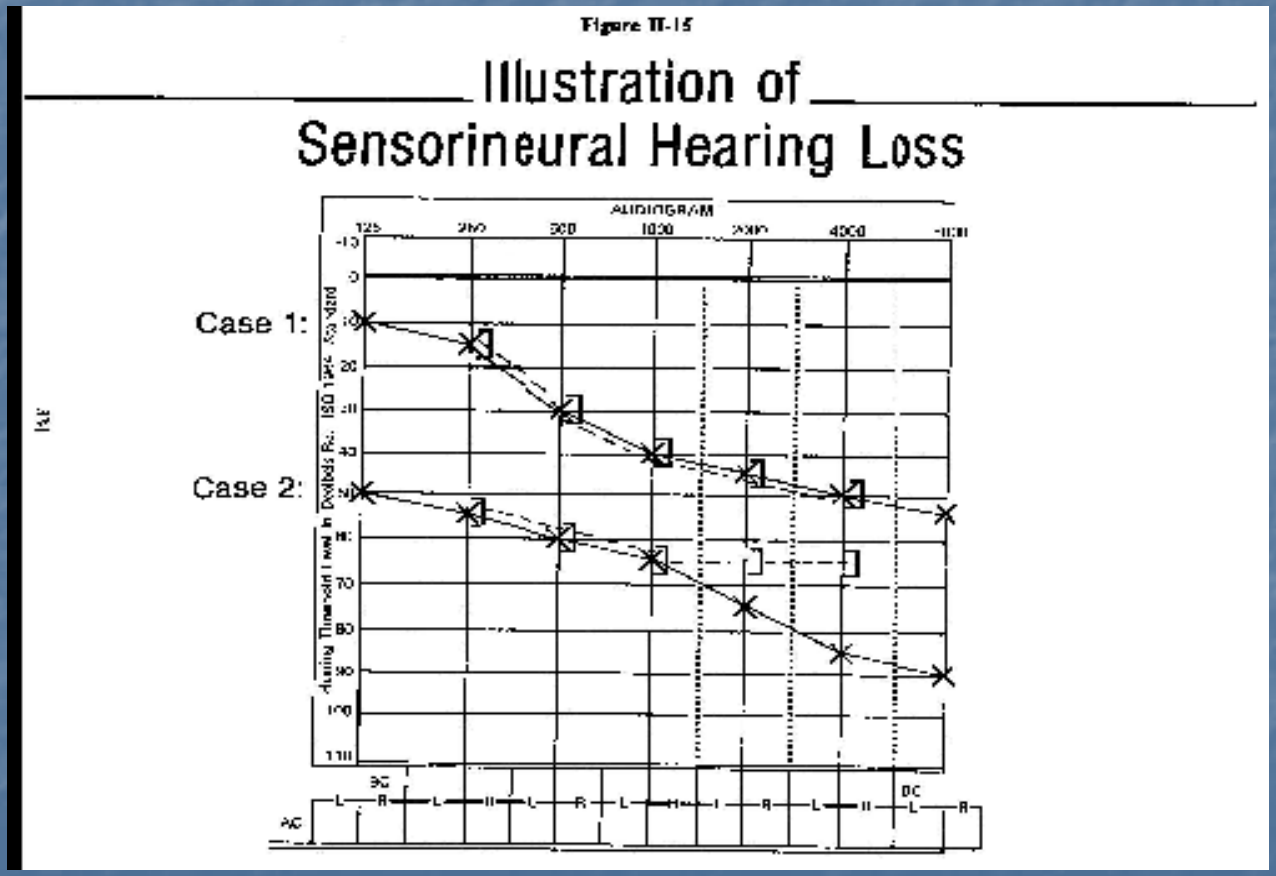
Conductive Hearing Loss



Sensorineural Hearing Loss

- Damage in the cochlea or auditory nerve
- Usually permanent
- May be mild to profound
- Perception that sound is quieter and may be distorted

Sensorineural Hearing Loss



Mixed Hearing Loss

- Conductive and sensorineural losses are both present
- Medical follow-up to monitor / improve conductive component
- On-going hearing evaluations to monitor loss

Auditory Neuropathy / Dyssynchrony

- Audiogram normal to profound
- Response to sound inconsistent
- Acoustic Reflexes Absent
- OAEs may be present
- ABR may be absent or inconsistent, cochlear microphone present
- Poor performance in noise
- Failure of the inner hair cells to communicate synchronously to auditory nerve

Auditory Neuropathy / Dyssynchrony

Simulation:

- www.hei.org/research/aip/audiodemos.htm

Page Ten: Auditory neuropathy/auditory dys-synchrony: New insights - *Linda J. Hood* (2002)

- http://www.audiologyonline.com/theHearingJournal/pdfs/HJ2002_02_pg10.pdf

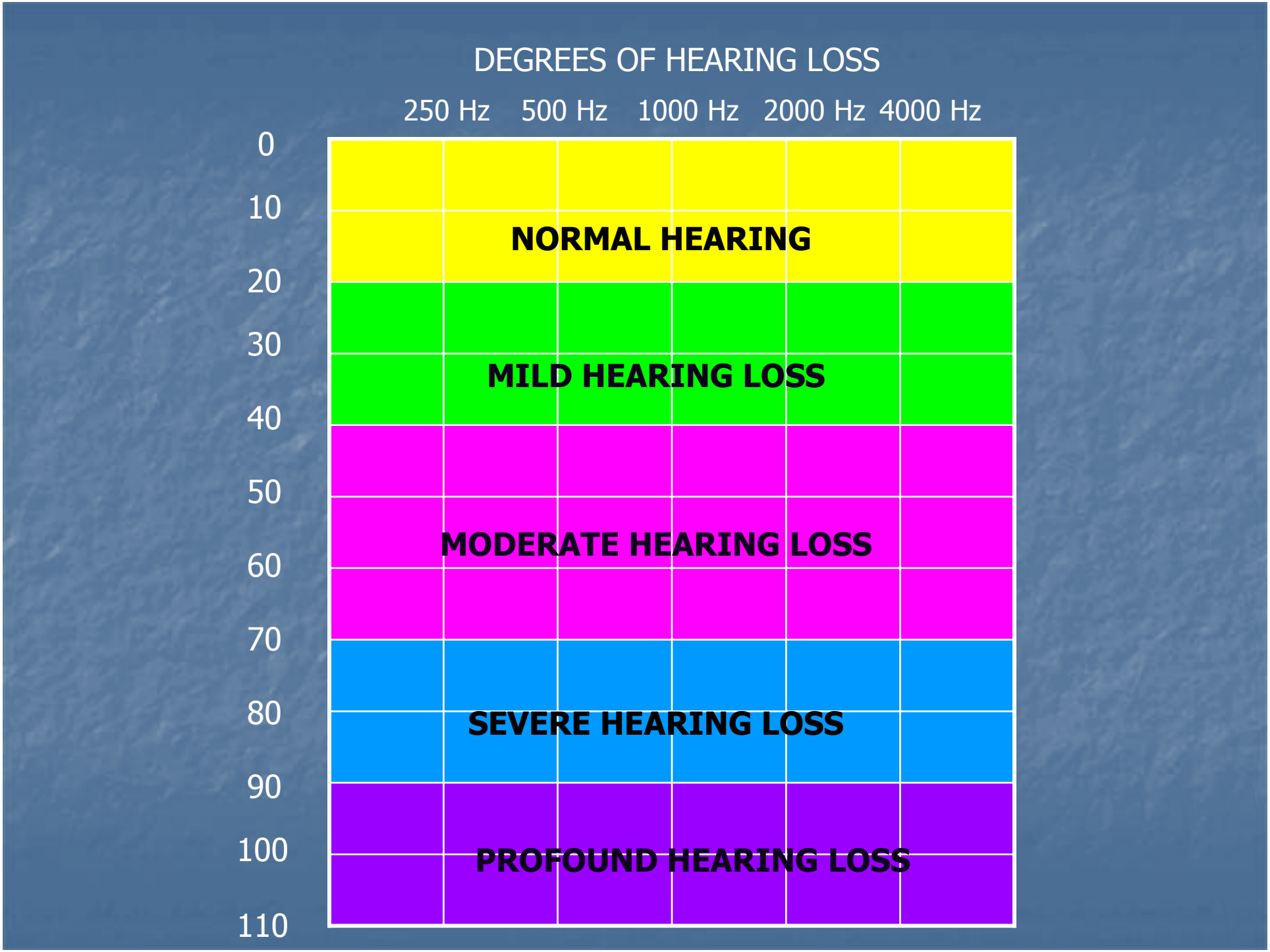
Central Auditory Processing Disorder - CAPD

- Auditory processing refers to how your brain recognizes and interprets sound
- Sometimes higher level centers in the brain affect the processing or interpretation of the information that is heard
- Children diagnosed with CAPD may have:
  - Normal hearing and intelligence
  - Trouble paying attention to and remembering information presented orally
  - Difficulty with multistep directions
  - Poor listening skills
  - Require additional time to process information
  - Lower than expected academic performance
  - Behavior problems
  - Language difficulty (phonemic awareness, vocabulary, abstract language)
  - Difficulty with reading, comprehension, spelling, and vocabulary

Central Auditory Processing Disorder - CAPD

National Institute on Deafness and other Communication Disorders

- http://www.nidcd.nih.gov/health/voice/auditory.asp


DEGREES OF HEARING LOSS
250 Hz
500 Hz
1000 Hz
2000 Hz
4000 Hz
0
10
20
30
40
50
60
70
80
90
100
110
NORMAL HEARING
MILD HEARING LOSS
MODERATE HEARING LOSS
SEVERE HEARING LOSS
PROFOUND HEARING LOSS

Degrees of Hearing Loss

- Normal 0-25 dB 
- Mild 25-40 dB 
- Moderate 40-70 dB 
- Severe 70-90 dB 
- Profound 90-110 dB

Relationship Of Hearing Loss To Listening And Learning Needs

Individual summaries for nine different levels / types of hearing loss

- www.kandersonaudconsulting.com
  - **16-25 dB Loss**
  - **26-40 dB Loss**
  - **41-55 dB Loss**
  - **56-70 dB Loss**
  - **71-90 dB / 91+ dB Loss**
  - **Unilateral**
  - **Mid-frequency / Reverse Slope**
  - **High Frequency**
  - **Fluctuating**

Relationship of Hearing Loss to Listening and Learning Needs

Child's Name: **Date:**

HIGH FREQUENCY HEARING LOSS

Possible Impact on the Understanding of Language and Speech	Possible Social Impact	Potential Educational Accommodations and Services
• Child can "hear" but can miss important fragments of speech. • Even a 26 – 40 dB loss in high frequency hearing may cause the child to miss 20% 30% of vital speech information if unamplified. • Consonant sounds s, f, th, k, sh, ch likely heard inconsistently, especially in the presence of noise. • May have difficulty understanding faint or distant speech, such as a student with a quiet voice speaking from across the classroom and will have much greater difficulty understanding speech when in low background noise and/or reverberation is present. • Many of the critical sounds for understanding speech are high pitched, quiet sounds, making them difficult to perceive; the words: cat, cap, call, and could be perceived as "ca," word endings, possessives, plurals and unstressed brief words are difficult to perceive and understand. • Speech production may be affected. • Use of amplification often indicated to learn language at a typical rate and ease learning.	• May be accused of selective hearing due to discrepancies in speech understanding in quiet versus noise. • Social problems may arise as child experiences difficulty understanding in noisy cooperative learning situations, lunch or recess. • May misinterpret peer conversations. • Child may be fatigued in classroom due to greater listening effort. • May appear inattentive, distractible or frustrated. • Could affect self concept.	• Student is at risk for educational difficulties. • Depending upon onset, degree and configuration of loss, child may experience delayed language and syntax development and articulation problems. • Possible difficulty learning some sound/letter associations in kindergarten and 1st grade classes. • Early evaluation of speech and language skills is suggested. • Educational monitoring and teacher inservice is warranted. • Will typically benefit from personal hearing aids and use of a sound-field or a personal FM system in the classroom. • Use of ear protection in noisy situations is imperative to prevent damage to inner ear structures and resulting progression of the hearing loss.

Comments:

Please Consider Indicated Items in the Child's Educational Program:

_____Teacher inservice and seating close to teacher _____Hearing monitoring at school every _____mos. _____Amplification monitoring

_____Consult your school district's audiologist _____Protect ears from noise to prevent more loss _____Educational support services/evaluation

_____Screening/evaluation of speech and language _____Note-taking, closed captioned films, visuals _____FM system trial period

_____Educational consultation/ program supervision by specialist(s) in hearing loss _____Regular contact with other children who are deaf or hard of hearing

_____Periodic educational monitoring such as October and April teacher/student completion of SIFTER, LIFE

NOTE: All children require full access to teacher instruction and educationally relevant peer communication to receive an appropriate education. Distance, noise in classroom and fragmentation caused by hearing loss prevent full access to spoken instruction. Appropriate acoustics, use of visuals, FM amplification, sign language, notetakers, communication partners, etc. increase access to instruction. Needs periodic hearing evaluation, rigorous amplification checks, and regular monitoring of access to instruction and classroom function (monitoring tools at www.hear2learn.com or www.SIFTERandLIFE.com).

Amplification

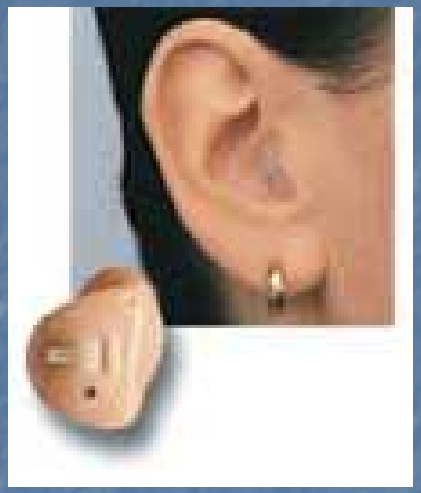
- Hearing Aids
- Bone Conduction Hearing Aids / BAHA
- Cochlear Implants
- Assistive Listening Devices

Types of Hearing Aids

- BTE – behind the ear
- ITE – in the ear
- ITC – in the canal
- CIC – completely in the canal

Hearing Aids

In-the-Ear (ITE)



In-the-canal (ITC)

Completely-in-the-Canal (CIC)

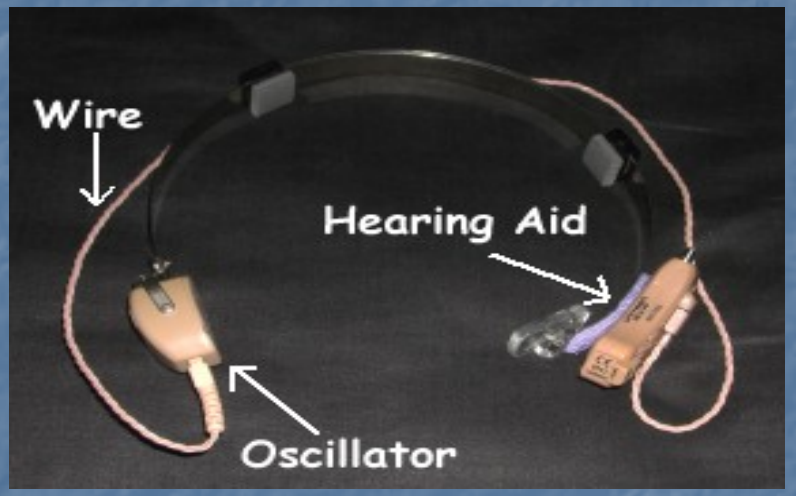
Behind-the-Ear (BTE)

Hearing Aids

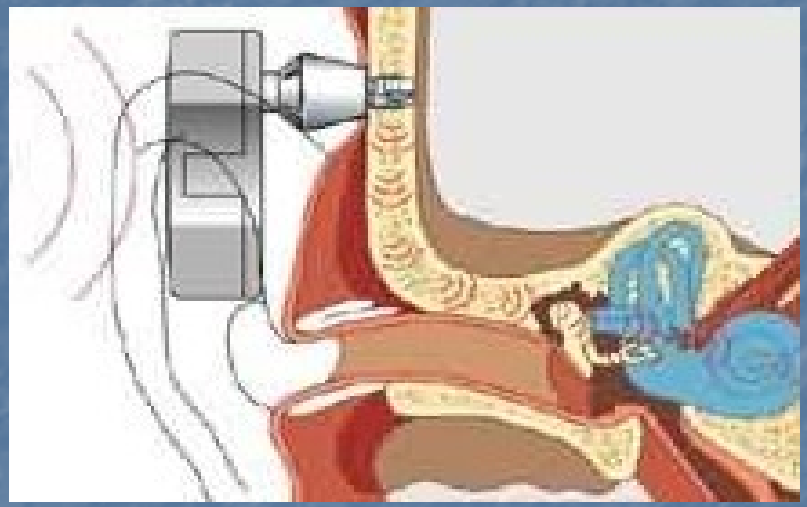
- **Digital:** Microprocessors (digital signal processing) and fitting flexibility provide maximum speech understanding. Most individualized and most expensive.
- **Digitally programmable:** Analog technology, which is programmed via Software (PC). Adapts conventional signal processing to the hearing loss. Economic and effective.
- **Analog:** Conventional technology for all degrees of hearing loss. Fitting modified with adjustments controls on the hearing instrument. Well-priced and proven technology.

Bone Conduction Hearing Aid

- Mixed and conductive losses due to chronic otitis media, congenital atresia, cholesteatoma, middle ear dysfunction
- Headband retention system
- Provides sound through bone conduction



BAHA –
Bone Anchored Hearing Aid



Pictures from Entific

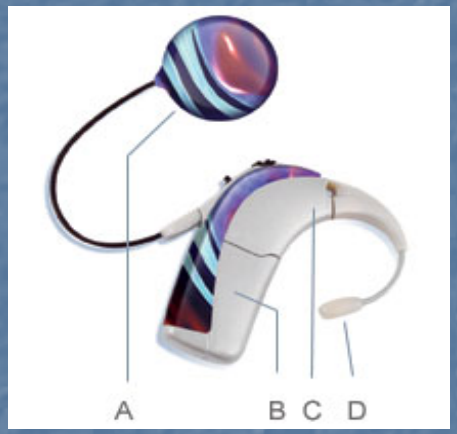
Cochlear Implants

Med-El Baby BTE Configuration

Cochlear Implants

Cochlear Corp. - Body Worn CI

Med-El - Behind-the-Ear CI



Advanced Bionics – Behind-the-Ear CI

Stimulator / Electrode Array

Picture from Cochlear Corporation

Assistive Listening Devices / FM Systems

- Improves the Signal to Noise ratio
  - From:
    - Signal to **NOISE**
  - To:
    - **SIGNAL** to Noise
  - 5-20 dB Improved S/N Ratio

Sound Field Amplification Systems

Lifeline Infrared Freedom 2

Lightspeed RedCat Infrared

Desktop / Portable FM Systems

Lifeline Patriot

Phonic Ear Front Row

Headset Style FM Systems

Lightspeed Personal FM

Phonic Ear Easy Listener

Lifeline Champion

Personal FM Systems

Phonak MLx

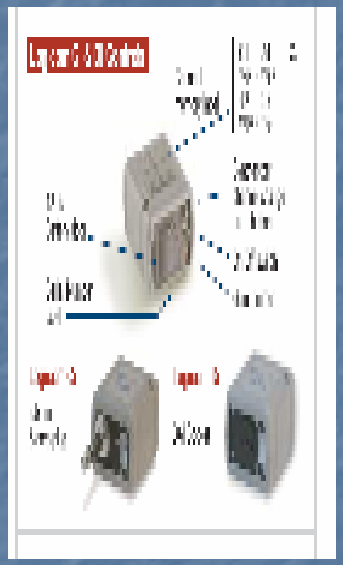
Sonovation Logicom XP

Phonak EduLink

Oticon Amigo

Cochlear Implant FM Systems

Sonovation Logicom CI



Cochlear ESPrit with Phonak Microlink CI

Advanced Bionics Harmony with iConnect to Phonak MLxi

Cochlear 3G Phonak Microlink adapter

Contact Information

Stacie Heckendorf
Educational Audiology Consultant
anastasia.heckendorf@wesp-dhh.wi.gov
608-355-2023

Holly Kloiber
Speech – Language Consultant
holly.kloiber@wesp-dhh.wi.gov
262-787-9580